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RESEARCH MEMORANDUM

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EXPERIMENTAL INVESTIGATION OF

LAMINAR-BOUNDARY-LAYER CONTROL ON AN AIRFOIL SECTION

EQUIPPED WITH SUCTION SLOTS LOCATED AT DISCONTINUITIES

IN THE SURFACE PRESSURE DISTRIBUTION

By Laurence K. Loftin, Jr., and Elmer A. Horton

Langley Aeronautical Laboratory
Langley Field, Va.

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
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SUMMARY

An experimental investigation has been made of a two-dimensional, 6.6-percent-thick, 6-foot-chord airfoil section equipped with suction slots for laminar-boundary-layer control. The airfoil section was designed to have favorable pressure gradients between the suction slots which were located at discontinuities in the airfoil surface pressure distribution. The upper surface contained nine slots, whereas the lower surface contained seven slots. The investigation indicated that the laminar boundary layer on this airfoil had the same extreme sensitivity to minute details of the model surface condition as has been found in other investigations of laminar-boundary-layer control.

INTRODUCTION

Extensive laminar boundary layers have been obtained at high Reynolds numbers by means of suction through discrete slots or porous surfaces in several wind-tunnel investigations (refs. 1 to 3). In these investigations, however, the attainment of extensive laminar boundary layers was found to be critically dependent upon minute details of the model surface condition. In an effort to decrease the sensitivity of the laminar boundary layer to minute surface imperfections, A. M. O. Smith of the Douglas Aircraft Co., Inc., designed an airfoil (designated the Douglas DESA-2) with a suction-slot arrangement which was markedly different from those employed in the investigations of references 1 and 3.

A short experimental investigation has been made in the Langley low-turbulence pressure tunnel of the Douglas DESA-2 airfoil. The purpose of the investigation was to determine whether the laminar boundary

layer on this model was materially less sensitive to surface conditions than in the investigations of references 1 to 3. The results of the present investigation are contained herein.

SYMBOLS

c   airfoil chord

l slot span

U_o free-stream velocity

u   local velocity

Q   quantity flow removed through an individual slot

ν kinematic viscosity

C_Q flow coefficient for an individual slot, $Q/U_o c l$

R   Reynolds number, $U_o c/\nu$

MODEL AND APPARATUS

Model

The airfoil section employed was 6.6 percent thick, had a design lift coefficient of 0.1, and was designated Douglas DESA-2. Ordinates of the airfoil are presented in table I. The airfoil was designed in such a way that the upper- and lower-surface pressure distributions contained nine and seven pressure discontinuities, respectively. A suction slot was located at each pressure discontinuity and the pressure gradients between slots were favorable. The theoretical pressure distribution about the airfoil is shown in figure 1 and a tabulation of the theoretical-pressure-distribution data is given in table II. The number and spacing of the slots and the magnitude of the pressure gradients between the slots were chosen only after very extensive laminar-boundary-layer stability calculations had been made. These calculations covered the Görtler type of instability as well as the usual two-dimensional type of instability. The design of the model was such that stability calculations indicated the boundary layer to be exceedingly stable at

Reynolds numbers of the order of 15.0×10^6. These calculations also indicated a maximum Reynolds number of 50.0×10^6 or more for which full-chord laminar flow might be expected.

The model of the DESA-2 boundary-layer suction airfoil had a 6-foot chord and was constructed of aluminum alloy. The ordinates of the model when installed in the tunnel are believed to have been within a range from about ±0.001 to ±0.002 inch of the specified ordinates. The surfaces were polished to a very high degree of smoothness. A sketch of the two-dimensional model which shows the method of construction, slot locations, and a detail of the slot shape and surface contour in the vicinity of the slot is presented in figure 2. The slot widths employed in the tests as well as the slot locations and spans are given in table III. The possibility of contamination of the slotted portions of the airfoil by turbulence originating at the spanwise ends of the slots dictated the variation in slot span with slot position. As indicated in figure 2, the slot widths could be adjusted by the plate forming the rear lip of the slot. Each slot opened into a separate compartment within the model. These compartments were connected to a variable-speed blower by ducts leading to a valve and manifold arrangement by which the flow in each slot could be adjusted. Photographs of the model installed in the tunnel and the ducting, valve, and manifold arrangements are shown in figures 3 and 4, respectively.

The quantity flow removed from each slot was measured by a calibrated orifice meter which was located in the duct leading from the model to the manifold, and the total flow removed from all of the slots was measured by a calibrated orifice meter located in the duct leading from the manifold to the variable-speed blower. A flush orifice within the chamber measured the chamber static pressure. For the rates of flow involved in the investigation, the velocities within the slot chambers were so low that the measured static pressure was assumed equal to the total pressure.

The flush orifices used to measure the airfoil pressure distribution were formed by drilling 0.005- to 0.008-inch-diameter holes in the surface of the model.

Wind Tunnel and Test Methods

The investigation was made in the Langley low-turbulence pressure tunnel. The two-dimensional model, when installed in the tunnel, completely spanned the 3-foot dimension of the 3-foot by $7\frac{1}{2}$-foot test section. A complete description of the tunnel is contained in reference 4.

The position of transition on the surfaces of the model was determined through the use of a medical stethoscope. For this purpose, the stethoscope was attached to a total-pressure tube which could be inserted into the airstream through the tunnel wall at several locations. The noise levels associated with laminar and turbulent flow are markedly different so that the listener can easily distinguish between the two types of flow. Observations of the flow fluctuations within the boundary layer were made with a hot-wire anemometer. The hot wire was attached to a remotely controlled probe which permitted movement of the hot wire to different positions along and above the surface.

RESULTS AND DISCUSSION

The initial tests consisted of measurements of the surface pressure distribution and extent of laminar flow on the airfoil at $0°$, $0.5°$, and $1.0°$ angle of attack. These tests were made at a Reynolds number of 5.78×10^6 with the design flow removal in each slot. A comparison of the desired and actual flow removal from each slot is shown in figure 5 in which the flow coefficient corresponding to each slot is plotted against chordwise position. The results of the experimental surface-pressure-distribution measurements for $0°$ and $1.0°$ angle of attack are presented in figure 6. The value of the free-stream velocity employed in both the pressure coefficient and the flow coefficient has been corrected for tunnel blockage according to the method given in reference 4. A comparison of the experimental pressure distributions of figure 6 with the theoretical distribution shown in figure 1 indicates that the general character of the theoretical distribution was realized experimentally. Because of small inaccuracies in the contour of the surface and lips of the slots, however, small pressure peaks are evident in the vicinity of several of the slots. The lift coefficients corresponding to angles of attack of $0°$ and $1.0°$ were not measured, nor have the experimental pressure distributions been integrated to obtain the lift coefficients. Comparison of the theoretical and experimental pressure distributions, however, indicates that the design lift coefficient probably occurred between $0°$ and $1.0°$ angle of attack.

In the first tests at a Reynolds number of 5.78×10^6, full-chord laminar flow was not realized. In an effort to find the causes of transition, extensive surveys were made with the stethoscope. In addition, some hot-wire measurements of the amplitude of laminar-boundary-layer oscillations at different points along the surface were made. The effects of variations in the suction quantities and angle of attack were also investigated. In general, it was found that transition was caused by the same type of minute surface imperfections as has been found to cause transition in other investigations. The laminar boundary layer was very

sensitive to small changes in slot and surface contour and to small bits of surface roughness which passed unnoticed by the naked eye and were found only as a result of stethoscopic or hot-wire surveys. The conclusion would, therefore, seem to be that no reduction in the sensitivity of the laminar boundary layer to small surface imperfections was shown by the DESA-2 boundary-layer suction airfoil as compared with other laminar-boundary-layer control schemes which have been investigated.

The maximum Reynolds number at which full-chord laminar flow was obtained was 5.78×10^6. This result does not necessarily mean that extensive laminar flow could not have been obtained at higher Reynolds numbers. Any effort to obtain extensive laminar flows at higher Reynolds numbers, however, would have required the same type of painstaking attention to surface condition as described in connection with the investigation reported in reference 3. There seemed to be little point in following such a cleanup procedure in the present investigation since the question posed in the basic purpose of the investigation had already been answered.

CONCLUDING REMARKS

An experimental investigation has been made of a two-dimensional, 6.6-percent-thick, 6-foot-chord airfoil section equipped with suction slots for laminar-boundary-layer control. The airfoil section was designed to have favorable pressure gradients between the suction slots which were located at discontinuities in the airfoil surface pressure distribution. The upper surface contained nine slots, whereas the lower surface contained seven slots. The investigation indicated that the laminar boundary layer on this airfoil had the same extreme sensitivity to minute details of the model surface condition as has been found in other investigations of laminar-boundary-layer control.

Langley Aeronautical Laboratory,
    National Advisory Committee for Aeronautics,
        Langley Field, Va., September 30, 1953.

REFERENCES

1. Burrows, Dale L., and Schwartzberg, Milton A.: Experimental Investigation of an NACA 64A010 Airfoil Section With 41 Suction Slots on Each Surface for Control of Laminar Boundary Layer. NACA TN 2644, 1952.

2. Braslow, Albert L., Burrows, Dale L., Tetervin, Neal, and Visconti, Fioravante: Experimental and Theoretical Studies of Area Suction for the Control of the Laminar Boundary Layer on an NACA 64A010 Airfoil. NACA Rep. 1025, 1951. (Supersedes NACA TN 1905 by Burrows, Braslow, and Tetervin and NACA TN 2112 by Braslow and Visconti.)

3. Loftin, Laurence K., Jr., and Horton, Elmer A.: Experimental Investigations of Boundary-Layer Suction Through Slots To Obtain Extensive Laminar Boundary Layers on a 15-Percent-Thick Airfoil Section at High Reynolds Numbers. NACA RM L52D02, 1952.

4. Von Doenhoff, Albert E., and Abbott, Frank T., Jr.: The Langley Two-Dimensional Low-Turbulence Pressure Tunnel. NACA TN 1283, 1947.

TABLE I.- ORDINATES OF DOUGLAS DESA-2 AIRFOIL SECTION

[Stations and ordinates given in percent of airfoil chord]

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
0.157	0.150	0.045	-0.002
.355	.293	.001	-.168
.633	.442	.018	-.336
.984	.594	.095	-.496
1.404	.749	.244	-.638
1.639	.826	.477	-.765
1.700	.846	.796	-.888
1.762	.865	1.199	-1.015
1.826	.885	1.679	-1.148
1.890	.904	2.230	-1.284
1.956	.921	3.537	-1.566
2.023	.940	5.108	-1.844
2.091	.958	6.918	-2.116
2.159	.975	8.952	-2.352
2.229	.993	9.493	-2.402
2.300	1.010	9.630	-2.414
2.372	1.026	9.769	-2.425
2.445	1.041	9.908	-2.436
2.522	1.056	10.048	-2.447
2.601	1.073	10.189	-2.455
2.681	1.089	10.330	-2.465
2.762	1.106	10.472	-2.474
2.845	1.123	10.615	-2.482
2.927	1.141	10.759	-2.488
3.012	1.159	10.904	-2.494
3.097	1.177	11.055	-2.496
3.183	1.195	11.211	-2.500
3.271	1.211	11.368	-2.507
3.359	1.229	11.525	-2.514
3.449	1.248	11.684	-2.523
3.818	1.324	11.842	-2.532
5.445	1.640	12.002	-2.540
7.307	1.946	12.162	-2.550
9.391	2.220	12.323	-2.560
9.528	2.235	12.485	-2.570
9.665	2.250	12.647	-2.581

TABLE I.- ORDINATES OF DOUGLAS DESA-2 AIRFOIL SECTION - Continued

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
9.804	2.264	12.810	-2.590
9.944	2.278	12.973	-2.601
10.085	2.292	13.135	-2.612
10.227	2.305	13.800	-2.654
10.370	2.317	16.562	-2.818
10.514	2.329	19.481	-2.947
10.659	2.340	19.668	-2.953
10.805	2.350	19.856	-2.958
10.954	2.359	20.044	-2.962
11.108	2.367	20.233	-2.966
11.266	2.377	20.422	-2.969
11.424	2.388	20.612	-2.972
11.582	2.400	20.802	-2.973
11.741	2.413	20.993	-2.975
14.370	2.659	21.185	-2.976
17.156	2.912	21.377	-2.976
20.085	3.114	21.569	-2.973
20.274	3.124	21.762	-2.970
20.462	3.133	21.957	-2.964
20.651	3.143	22.159	-2.956
20.840	3.151	22.365	-2.949
21.029	3.158	22.573	-2.947
21.220	3.164	22.781	-2.946
21.410	3.168	22.989	-2.946
21.601	3.169	23.198	-2.947
21.793	3.167	23.407	-2.948
21.991	3.165	23.616	-2.951
22.195	3.166	23.827	-2.955
22.400	3.169	24.038	-2.956
22.606	3.174	24.250	-2.959
22.812	3.180	25.095	-2.974
23.018	3.187	25.945	-2.989
23.224	3.195	29.395	-3.038
26.568	3.353	30.267	-3.042
29.984	3.494	31.143	-3.043
30.835	3.520	31.363	-3.042
31.050	3.524	31.582	-3.041
31.267	3.528	31.802	-3.039
31.484	3.533	32.022	-3.037
31.700	3.537	32.243	-3.033
31.917	3.540	32.463	-3.030
32.134	3.543	32.684	-3.025
32.351	3.545	32.904	-3.019
32.569	3.546	33.125	-3.012
32.786	3.547	33.346	-3.004
33.004	3.546	33.567	-2.993

TABLE I.- ORDINATES OF DOUGLAS DESA-2 AIRFOIL SECTION - Continued

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
33.222	3.544	33.789	-2.979
33.440	3.540	34.019	-2.962
33.658	3.535	34.254	-2.948
33.880	3.527	34.490	-2.936
34.109	3.519	34.726	-2.926
34.341	3.513	34.962	-2.918
34.574	3.509	35.199	-2.910
34.807	3.506	35.435	-2.903
35.040	3.504	35.672	-2.897
35.273	3.502	35.909	-2.892
35.506	3.502	36.147	-2.888
35.739	3.501	36.384	-2.882
35.973	3.501	36.620	-2.880
36.206	3.502	40.423	-2.826
37.140	3.506	41.374	-2.808
40.881	3.529	42.325	-2.787
41.815	3.531	42.563	-2.781
42.050	3.531	42.800	-2.774
42.284	3.531	43.038	-2.767
42.518	3.530	43.275	-2.760
42.753	3.529	43.512	-2.753
42.987	3.527	43.750	-2.745
43.220	3.525	43.987	-2.735
43.453	3.522	44.224	-2.725
43.686	3.519	44.461	-2.714
43.919	3.514	44.698	-2.700
44.151	3.509	44.938	-2.685
44.384	3.501	45.184	-2.670
44.611	3.493	45.431	-2.655
44.848	3.482	45.678	-2.643
45.086	3.471	45.925	-2.632
45.328	3.462	46.171	-2.620
45.570	3.454	46.418	-2.611
45.811	3.447	46.665	-2.602
46.052	3.442	46.911	-2.591
46.294	3.436	47.157	-2.583
46.535	3.431	47.403	-2.574
46.776	3.427	47.648	-2.566
47.017	3.422	47.893	-2.556
47.258	3.418	48.137	-2.547
47.499	3.414	52.040	-2.410
48.461	3.397	53.007	-2.369
52.268	3.317	53.248	-2.359
53.209	3.286	53.489	-2.347
53.444	3.277	53.730	-2.336

TABLE I.- ORDINATES OF DOUGLAS DESA-2 AIRFOIL SECTION - Continued

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
53.678	3.268	53.970	-2.324
53.912	3.258	54.210	-2.310
54.146	3.249	54.445	-2.297
54.379	3.238	54.689	-2.283
54.612	3.227	54.928	-2.266
54.845	3.216	55.167	-2.248
55.077	3.203	55.405	-2.228
55.309	3.190	55.643	-2.207
55.540	3.174	55.882	-2.185
55.771	3.156	56.128	-2.163
56.004	3.134	56.378	-2.143
56.245	3.112	56.627	-2.123
56.487	3.094	56.877	-2.105
56.729	3.078	57.126	-2.089
56.971	3.064	57.374	-2.073
57.212	3.050	57.623	-2.056
57.453	3.037	57.871	-2.042
57.694	3.024	58.118	-2.028
57.934	3.012	58.366	-2.013
58.174	3.000	58.612	-2.000
58.414	2.990	58.858	-1.986
58.653	2.978	59.840	-1.933
58.892	2.967	63.701	-1.739
59.843	2.921	63.938	-1.725
63.576	2.741	64.175	-1.712
64.489	2.689	64.411	-1.699
64.713	2.676	64.647	-1.685
64.939	2.661	64.882	-1.669
65.163	2.646	65.116	-1.654
65.388	2.630	65.350	-1.639
65.611	2.613	65.584	-1.621
65.834	2.596	65.817	-1.605
66.058	2.577	66.049	-1.587
66.281	2.558	66.281	-1.566
66.503	2.537	66.511	-1.545
66.725	2.515	66.742	-1.520
66.947	2.490	66.978	-1.493
67.178	2.462	67.221	-1.466
67.412	2.435	67.465	-1.444
67.646	2.412	67.709	-1.423
67.878	2.390	67.952	-1.404
68.111	2.370	68.195	-1.387
68.343	2.351	68.437	-1.371
68.574	2.333	68.680	-1.355
68.804	2.316	68.921	-1.341

TABLE I.- ORDINATES OF DOUGLAS DESA-2 AIRFOIL SECTION - Continued

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
69.034	2.299	69.162	-1.328
69.263	2.283	69.403	-1.314
69.492	2.267	70.354	-1.268
69.720	2.251	71.294	-1.225
69.947	2.236	74.941	-1.094
70.849	2.177	78.395	-.999
74.339	1.949	81.631	-.916
75.182	1.890	84.641	-.835
75.391	1.875	87.408	-.741
75.600	1.858	87.572	-.735
75.809	1.843	87.736	-.728
76.016	1.827	87.898	-.722
76.222	1.811	88.060	-.715
76.426	1.794	88.220	-.707
76.630	1.777	88.379	-.699
76.834	1.758	88.538	-.691
77.036	1.739	88.695	-.682
77.237	1.719	88.852	-.673
77.437	1.697	89.010	-.663
77.637	1.674	89.168	-.653
77.836	1.650	89.325	-.644
78.038	1.624	89.481	-.637
78.247	1.598	89.636	-.630
78.456	1.573	89.791	-.623
78.664	1.551	89.944	-.616
78.871	1.530	92.248	-.524
79.078	1.510	94.258	-.449
79.283	1.491	95.974	-.371
79.488	1.473	97.388	-.289
79.692	1.455	98.497	-.203
79.896	1.438	99.304	-.101
80.098	1.422	99.812	-.033
80.899	1.359	100	0
83.958	1.143		
86.769	.942		
86.935	.928		
87.101	.914		
87.266	.900		
87.430	.887		
87.593	.874		
87.755	.861		
87.916	.847		
88.075	.833		
88.234	.818		
88.391	.803		

TABLE I.- ORDINATES OF DOUGLAS DESA-2 AIRFOIL SECTION - Concluded

Upper surface	
Station	Ordinate
88.547	0.786
88.702	.769
88.856	.750
89.012	.730
89.171	.709
89.332	.690
89.492	.673
89.651	.657
89.809	.642
89.966	.628
90.122	.614
90.276	.601
90.430	.589
90.582	.577
90.733	.565
90.883	.554
91.032	.543
91.180	.532
91.760	.493
93.891	.368
95.712	.274
97.211	.196
98.393	.119
99.264	.055
99.807	.015
100	0

TABLE II.- THEORETICAL-PRESSURE-DISTRIBUTION DATA FOR DOUGLAS

DESA-2 AIRFOIL SECTION AT DESIGN LIFT

Upper surface		Lower surface	
Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$	Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$
0.157	1.1029	0.045	0.6161
.355	1.1546	.001	.1183
.633	1.1922	.018	.0177
.984	1.2243	.095	.3056
1.404	1.2674	.244	.6427
1.639	1.2875	.477	.7683
1.700	------	.796	.8160
1.762	------	1.199	.8499
1.826	------	1.679	.8892
1.890	1.3028	2.230	.9355
1.956	------	3.537	.9994
2.023	------	5.108	1.0617
2.091	------	6.918	1.1196
2.159	1.3207	8.952	1.1675
2.229	1.3248	9.493	1.1796
2.300	1.3294	9.630	------
2.372	1.3319	9.769	------
2.445	1.3060	9.908	------
2.522	1.2381	10.048	1.1916
2.601	1.1929	10.189	------
2.681	1.1835	10.330	1.1966
2.762	1.1837	10.472	1.1990
2.845	1.1868	10.615	1.2012
2.927	------	10.759	1.2030
3.012	------	10.904	1.1716
3.097	1.1964	11.055	1.0774
3.183	------	11.211	1.0654
3.271	------	11.368	1.0661
3.359	------	11.525	1.0685
3.449	1.2078	11.684	1.0723
3.818	1.2184	11.842	1.0770
5.445	1.2560	12.002	------
7.307	1.2884	12.162	------
9.391	1.3177	12.323	------
9.528	------	12.485	1.0862
9.665	------	12.647	------
9.804	------	12.810	------

TABLE II.- THEORETICAL-PRESSURE-DISTRIBUTION DATA FOR DOUGLAS

DESA-2 AIRFOIL SECTION AT DESIGN LIFT - Continued

Upper surface		Lower surface	
Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$	Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$
9.944	1.3230	12.973	------
10.085	------	13.135	1.0958
10.227	------	13.800	1.1071
10.370	1.3243	16.562	1.1451
10.514	1.3278	19.481	1.1818
10.659	1.3246	19.668	------
10.805	1.3071	19.856	------
10.954	1.2426	20.044	------
11.108	1.1837	20.233	1.1888
11.266	1.1759	20.422	------
11.424	1.1811	20.612	------
11.582	1.1848	20.802	------
11.741	1.1877	20.993	1.1991
14.370	1.2341	21.185	1.1992
17.156	1.2733	21.377	1.2014
20.085	1.3122	21.569	1.2030
20.274	------	21.762	1.1977
20.462	------	21.957	1.1530
20.651	------	22.159	1.0833
20.840	1.3207	22.365	1.0661
21.029	------	22.573	1.0689
21.220	1.3236	22.781	1.0731
21.410	1.3264	22.989	1.0758
21.601	1.3294	23.198	------
21.793	1.3026	23.407	1.0816
21.991	1.2179	23.616	------
22.195	1.1779	23.827	------
22.400	1.1809	24.038	------
22.606	1.1846	24.250	1.0904
22.812	1.1874	25.095	1.1008
23.018	1.1914	25.945	1.1128
23.224	1.1929	29.395	1.1537
26.568	1.2388	30.267	1.1642
29.984	1.2814	31.143	1.1722
30.835	1.2910	31.363	------
31.050	------	31.582	------
31.267	------	31.802	------
31.484	------	32.022	1.1818
31.700	1.3005	32.243	------
31.917	------	32.463	------
32.134	------	32.684	------
32.351	------	32.904	1.1903
32.569	1.3110	33.125	1.1936
32.786	------	33.346	1.1964
33.004	1.3161	33.567	1.1973
33.222	1.3184	33.789	1.1692

TABLE II.- THEORETICAL-PRESSURE-DISTRIBUTION DATA FOR DOUGLAS

DESA-2 AIRFOIL SECTION AT DESIGN LIFT - Continued

Upper surface		Lower surface	
Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$	Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$
33.440	1.3218	34.019	1.0721
33.658	1.3138	34.254	1.0632
33.880	1.2432	34.490	1.0654
34.109	1.1742	34.726	1.0667
34.341	1.1755	34.962	1.0681
34.574	1.1753	35.199	------
34.807	1.1774	35.435	------
35.040	1.1792	35.672	1.0735
35.273	1.1798	35.909	------
35.506	------	36.147	------
35.739	------	36.384	------
35.973	------	36.620	1.0804
36.206	1.1894	40.423	1.1126
37.140	1.1972	41.374	1.1198
40.881	1.2321	42.325	1.1289
41.815	1.2406	42.563	------
42.050	------	42.800	------
42.284	------	43.038	------
42.518	------	43.275	1.1359
42.753	1.2495	43.512	------
42.987	------	43.750	------
43.220	------	43.987	1.1425
43.453	------	44.224	1.1428
43.686	1.2584	44.461	1.1470
43.919	1.2602	44.698	1.1381
44.151	1.2629	44.938	1.0818
44.384	1.2654	45.184	1.0576
44.611	1.2674	45.431	1.0564
44.848	1.2486	45.678	1.0580
45.086	1.1753	45.925	1.0599
45.328	1.1720	46.171	1.0619
45.570	1.1729	46.418	------
45.811	1.1755	46.665	------
46.052	1.1774	46.911	------
46.294	------	47.157	1.0696
46.535	1.1811	47.403	------
46.776	------	47.648	------
47.017	------	47.893	------
47.258	------	48.137	1.0762
47.499	1.1877	52.040	1.0998
48.461	1.1962	53.007	1.1050
52.268	1.2241	53.248	1.1065
53.209	1.2305	53.489	1.1080
53.444	------	53.730	1.1092
53.678	------	53.970	1.1103
53.912	------	54.210	1.1115

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TABLE II.- THEORETICAL-PRESSURE-DISTRIBUTION DATA FOR DOUGLAS

DESA-2 AIRFOIL SECTION AT DESIGN LIFT - Continued

Upper surface		Lower surface	
Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$	Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$
54.146	1.2370	54.445	1.1128
54.379	------	54.689	1.1139
54.612	------	54.928	1.1164
54.845	1.2410	55.167	1.1170
55.077	1.2430	55.405	1.1181
55.309	1.2448	55.643	1.1177
55.540	1.2468	55.882	1.0777
55.771	1.2477	56.128	1.0157
56.004	1.1827	56.378	1.0120
56.245	1.1287	56.627	1.0132
56.487	1.1293	56.877	1.0155
56.729	1.1293	57.126	1.0161
56.971	1.1315	57.374	1.0165
57.212	------	57.623	1.0173
57.453	------	57.871	1.0197
57.694	------	58.118	1.0201
57.934	1.1364	58.366	1.0207
58.174	------	58.612	1.0223
58.414	------	58.858	1.0239
58.653	------	59.840	1.0282
58.892	1.1428	63.701	1.0447
59.843	1.1488	63.938	------
63.576	1.1707	64.175	------
64.489	1.1755	64.411	------
64.713	------	64.647	1.0492
64.939	------	64.882	------
65.163	------	65.116	------
65.388	1.1798	65.350	------
65.611	------	65.584	1.0535
65.834	------	65.817	------
66.058	1.1816	66.049	1.0562
66.281	1.1850	66.281	1.0572
66.503	1.1833	66.511	1.0576
66.725	1.1814	66.742	1.0492
66.947	1.1122	66.978	.9608
67.178	1.0523	67.221	.9324
67.412	1.0469	67.465	.9332
67.646	1.0494	67.709	.9349
67.878	1.0504	67.952	.9362
68.111	1.0535	68.195	.9374
68.343	------	68.437	.9380
68.574	------	68.680	------
68.804	------	68.921	------
69.034	1.0586	69.162	------
69.263	------	69.403	.9425
69.492	------	70.354	.9471

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TABLE II.- THEORETICAL-PRESSURE-DISTRIBUTION DATA FOR DOUGLAS

DESA-2 AIRFOIL SECTION AT DESIGN LIFT - Continued

Upper surface		Lower surface	
Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$	Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$
69.720	------	71.294	0.9508
69.947	1.0654	74.941	.9683
70.849	1.0712	78.395	.9837
74.339	1.0904	81.631	.9976
75.182	1.0937	84.641	1.0102
75.391	1.0941	87.408	1.0217
75.600	1.0954	87.572	------
75.809	1.0966	87.736	------
76.016	1.0979	87.898	------
76.222	1.0983	88.060	1.0262
76.426	1.0994	88.220	1.0276
76.630	1.1017	88.379	1.0284
76.834	1.1019	88.538	1.0294
77.036	1.1029	88.695	1.0306
77.237	1.1046	88.852	1.0074
77.437	1.1067	89.010	.9805
77.637	1.1057	89.168	.9807
77.836	1.0975	89.325	.9809
78.038	1.0096	89.481	.9811
78.247	.9785	89.636	.9815
78.456	.9781	89.791	------
78.664	.9797	89.944	.9821
78.871	.9801	92.248	.9962
79.078	.9805	94.258	1.0064
79.283	.9821	95.974	1.0149
79.488	.9833	97.388	1.0213
79.692	.9837	98.497	1.0084
79.896	.9837	99.304	.9543
80.098	.9841	99.812	.8214
80.899	.9864	100	------
83.958	.9986		
86.769	1.0054		
86.935	------		
87.101	------		
87.266	------		
87.430	1.0094		
87.593	------		
87.755	------		
87.916	------		
88.075	1.0120		
88.234	1.0134		
88.391	1.0138		
88.547	1.0159		
88.702	1.0144		
88.856	1.0078		
89.012	.9498		

TABLE II.- THEORETICAL-PRESSURE-DISTRIBUTION DATA FOR DOUGLAS

DESA-2 AIRFOIL SECTION AT DESIGN LIFT - Concluded

Upper surface	
Station, percent chord	$\left(\dfrac{u}{U_o}\right)^2$
89.171	0.8972
89.332	.8923
89.492	.8930
89.651	.8940
89.809	------
89.966	.8949
90.122	------
90.276	------
90.430	------
90.582	.8974
90.733	------
90.883	------
91.032	------
91.180	.8987
91.760	.8993
93.891	.9042
95.712	.9113
97.211	.9134
98.393	.8782
99.264	.8290
99.807	.7524
100	0

TABLE III.- SLOT DATA

Upper surface			
Slot number	Station, percent chord	Slot width, in.	Slot span, in.
1	2.5	1.5×10^{-3}	31.99
2	11.0	3	30.24
3	21.9	3.5	28.01
4	33.85	4	25.56
5	44.9	5	23.30
6	56.0	5.5	21.02
7	66.95	6	18.78
8	78.0	6.5	16.51
9	89.0	7	14.26
Lower surface			
10	10.92	2.5	30.26
11	22.0	3.5	27.99
12	33.85	4.5	25.56
13	44.9	5	23.30
14	55.9	5.5	21.04
15	66.9	6	18.78
16	88.85	7	14.28
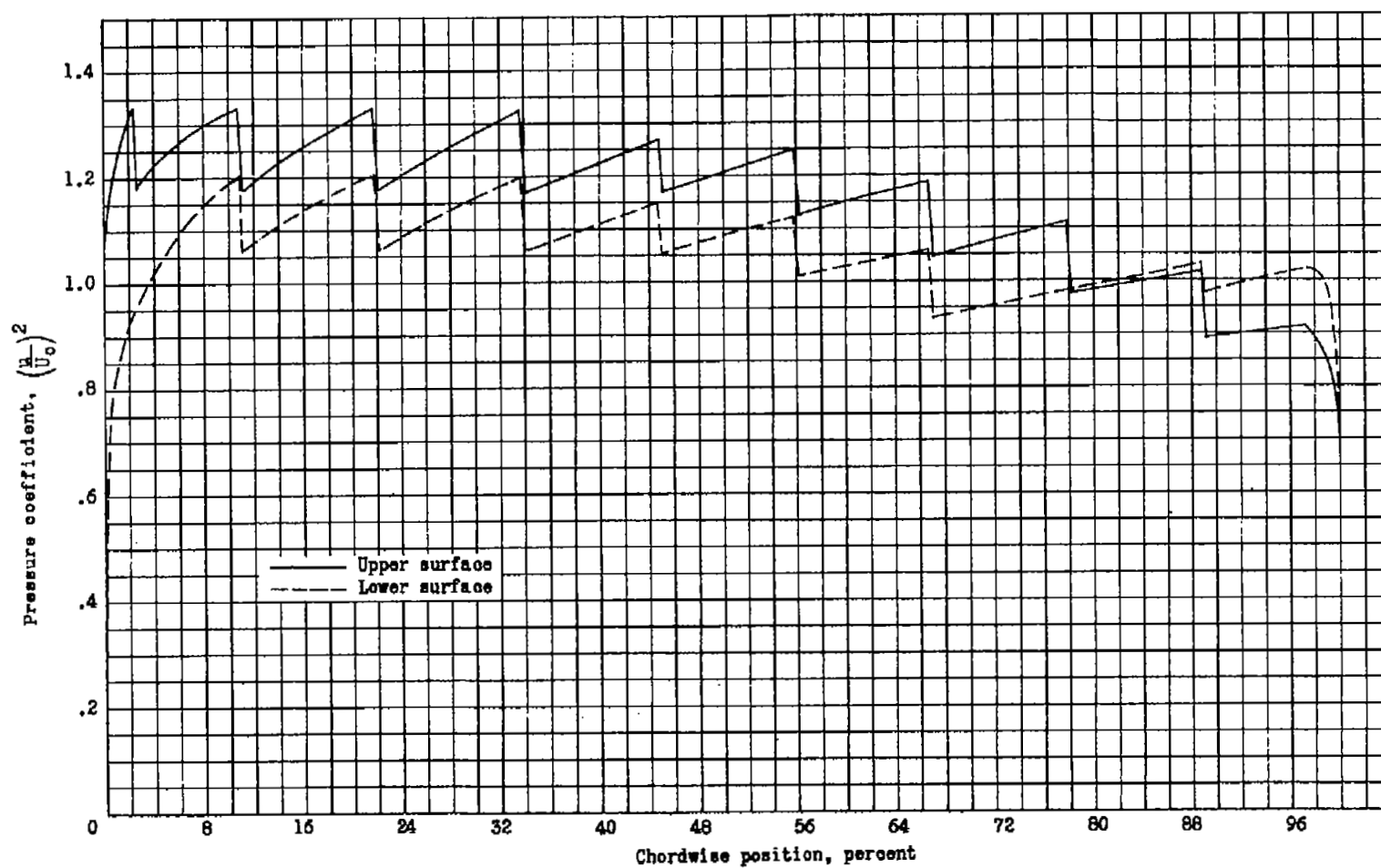
Figure 1.- Theoretical pressure distribution about Douglas DESA-2 airfoil section at design lift coefficient of 0.1.
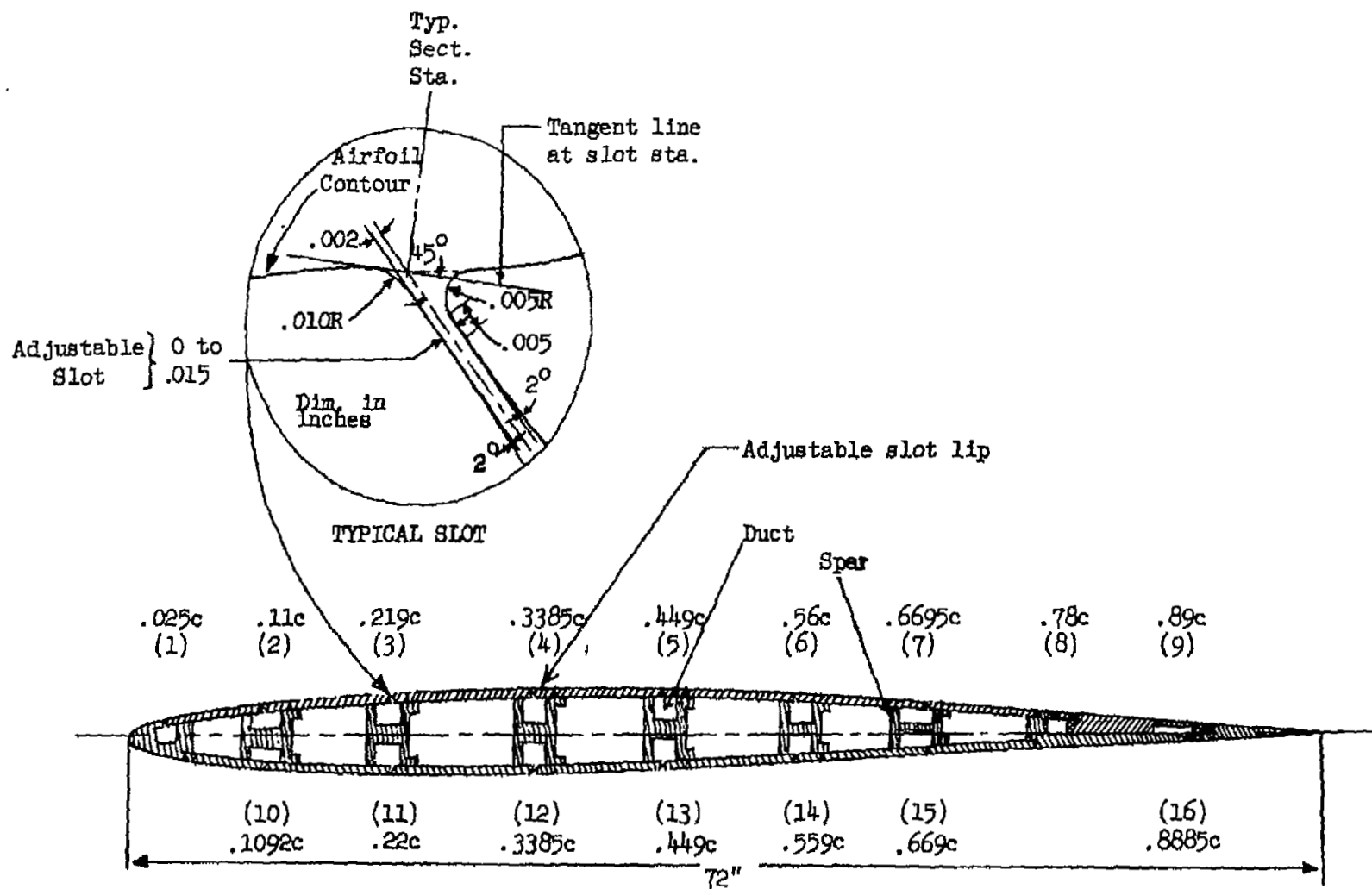
Figure 2.- Cross-sectional view of Douglas DESA-2 boundary-layer suction
model showing method of construction and design of slots.
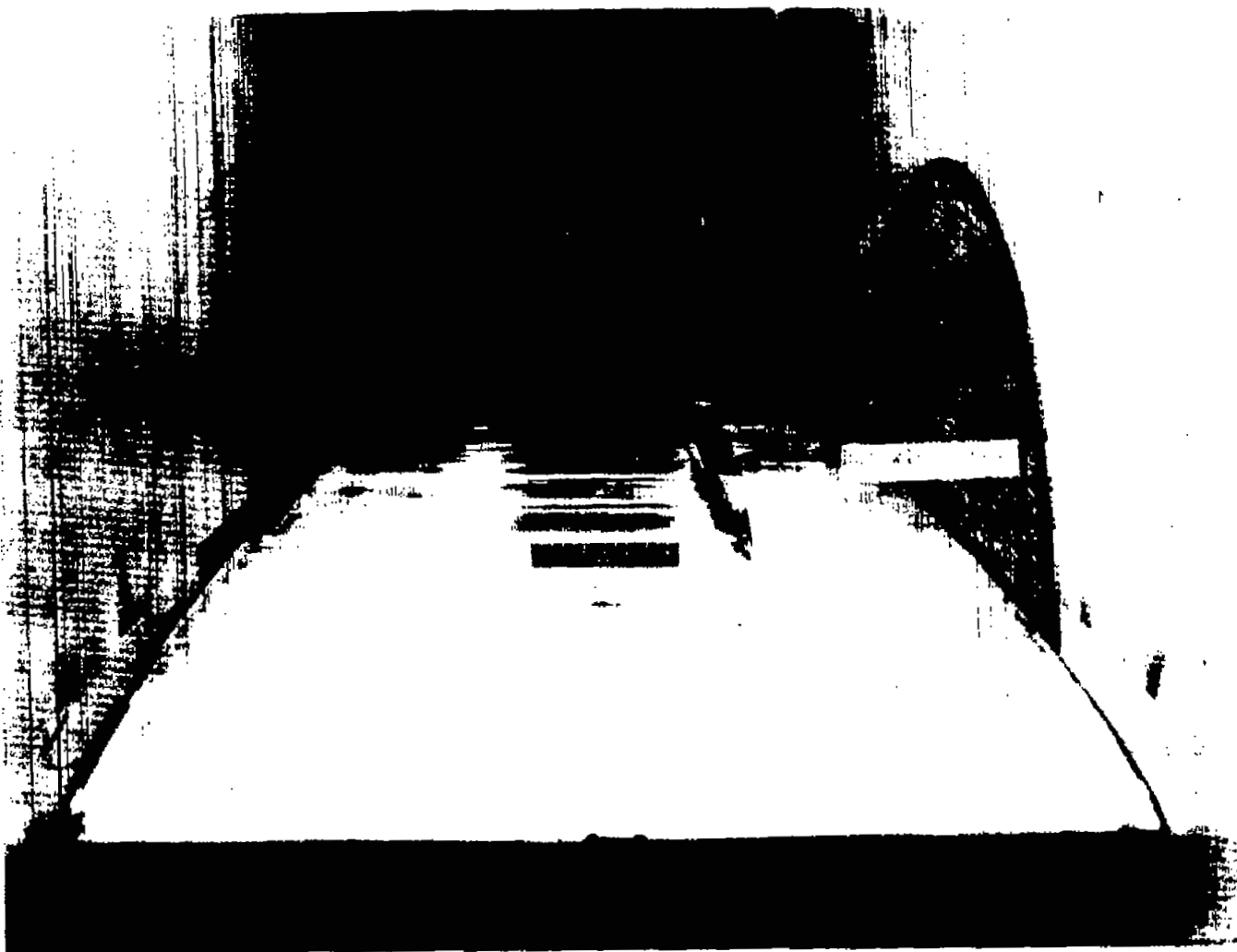
L-76321.1

Figure 3.- Photograph of Douglas DESA-2 airfoil model mounted in Langley low-turbulence pressure tunnel.

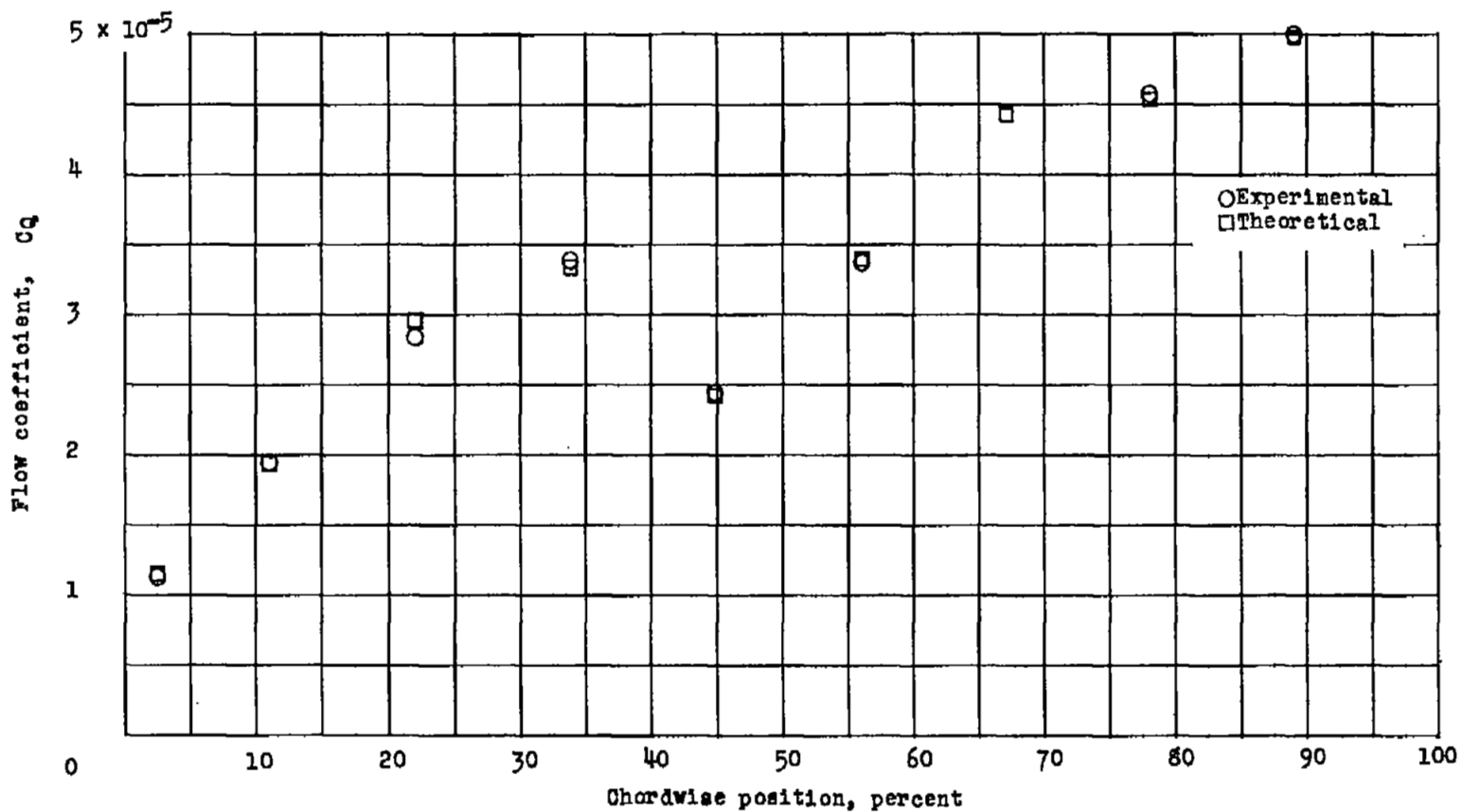L-76324.1

(a) View showing ducts, valves, and manifold.
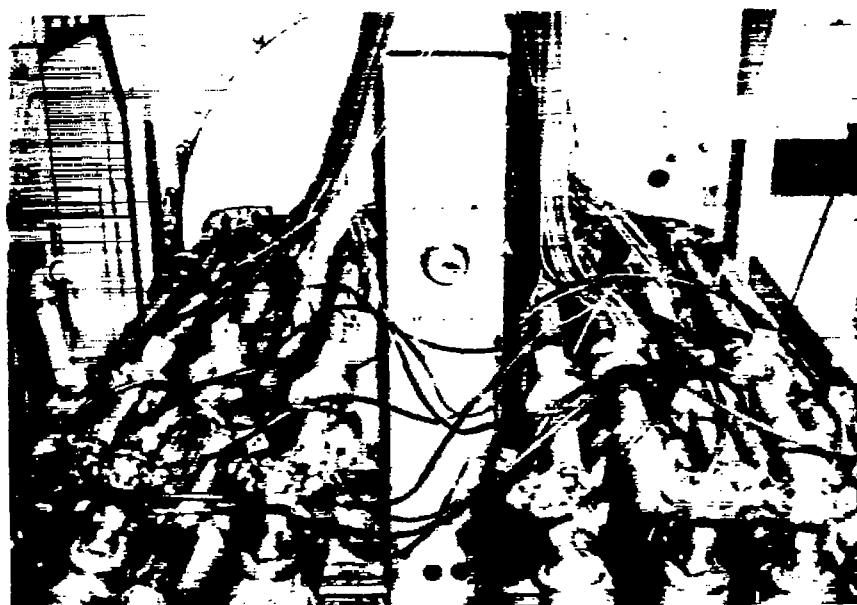
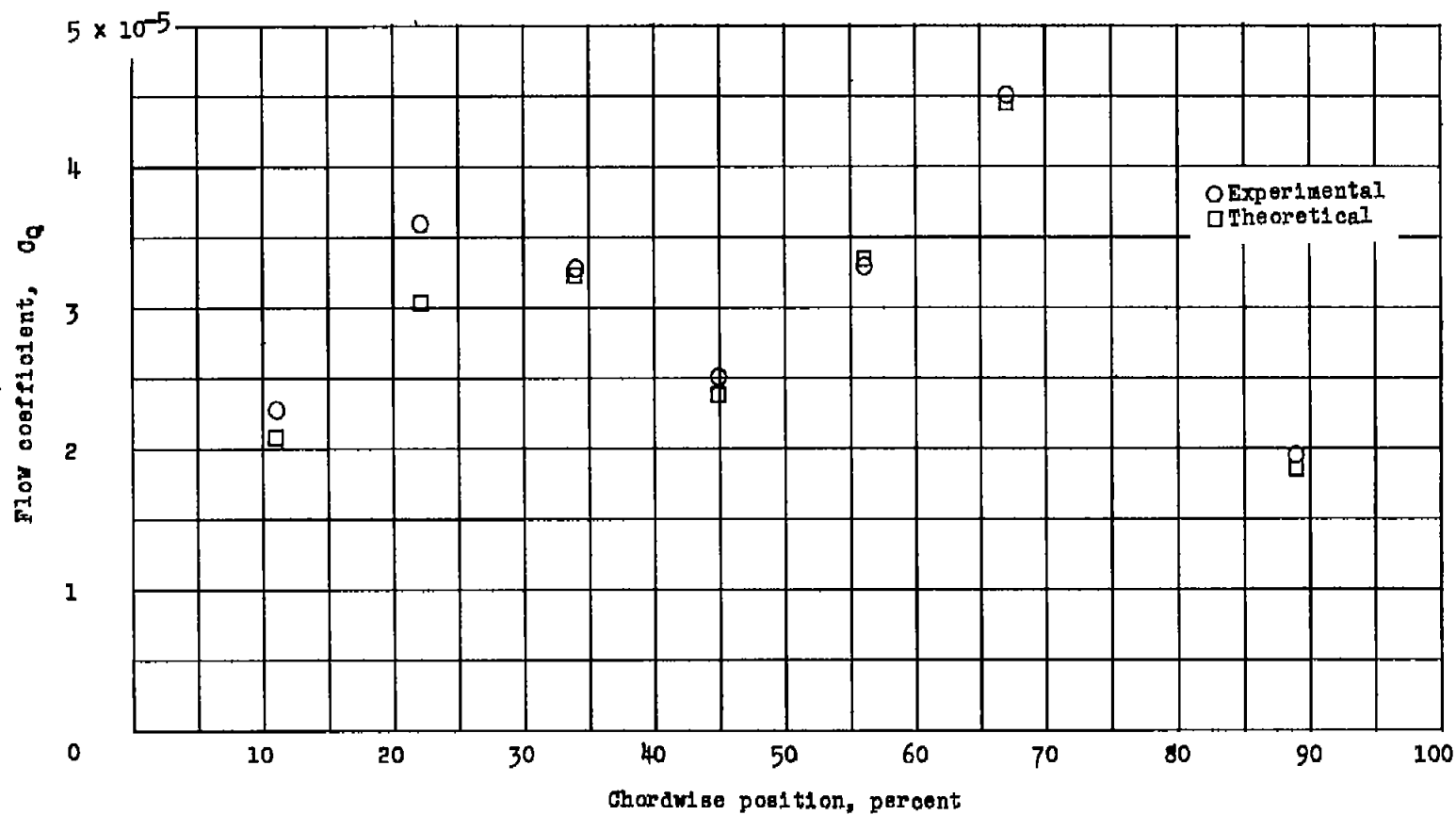L-76325.1

(b) View showing ducts, valves, and orifice plate holders.

Figure 4.- Photographs showing ducting, valve, and manifold arrangements
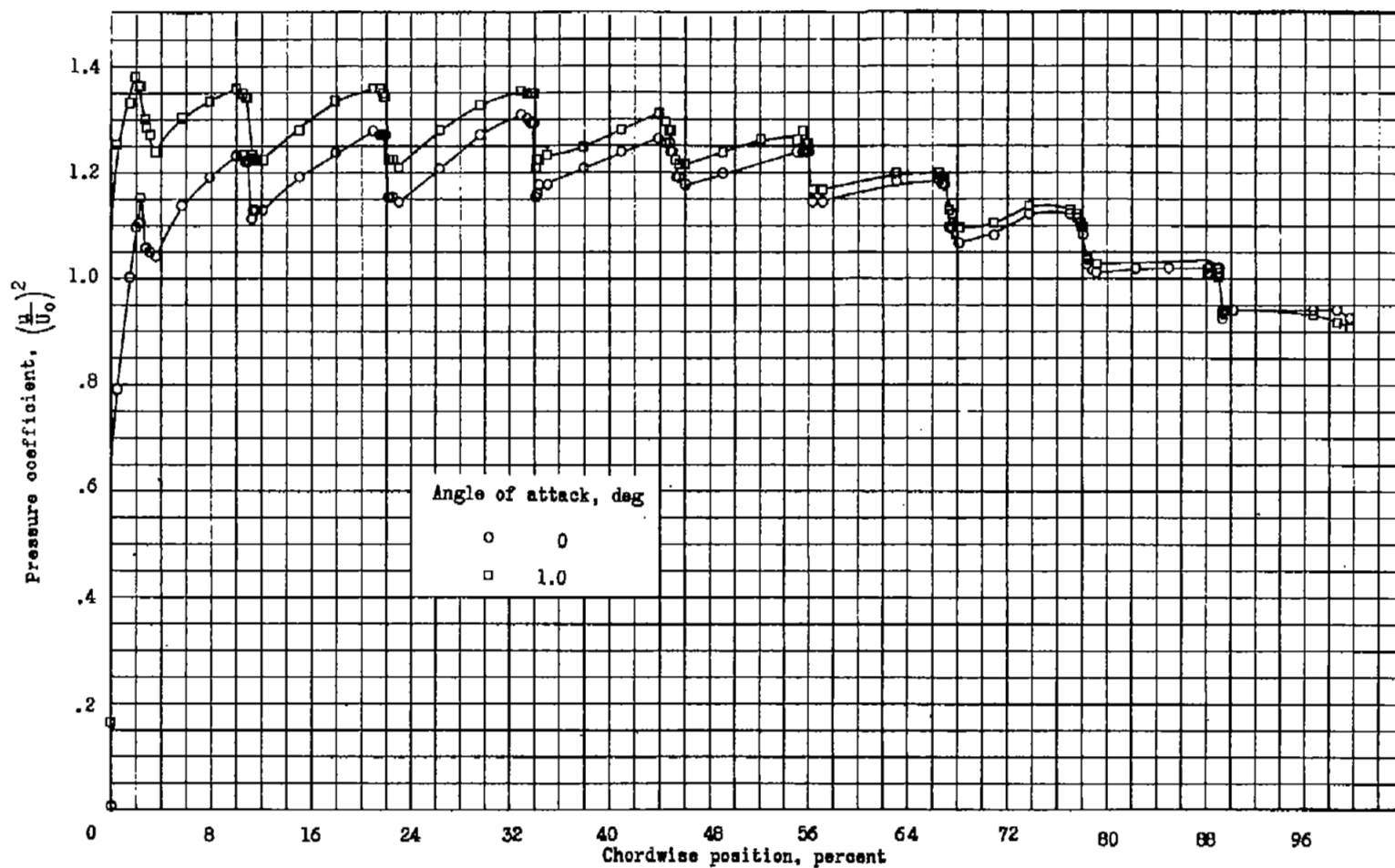for Douglas DESA-2 airfoil model.

(a) Upper surface.

Figure 5.- Theoretical and experimental distribution of flow coefficient
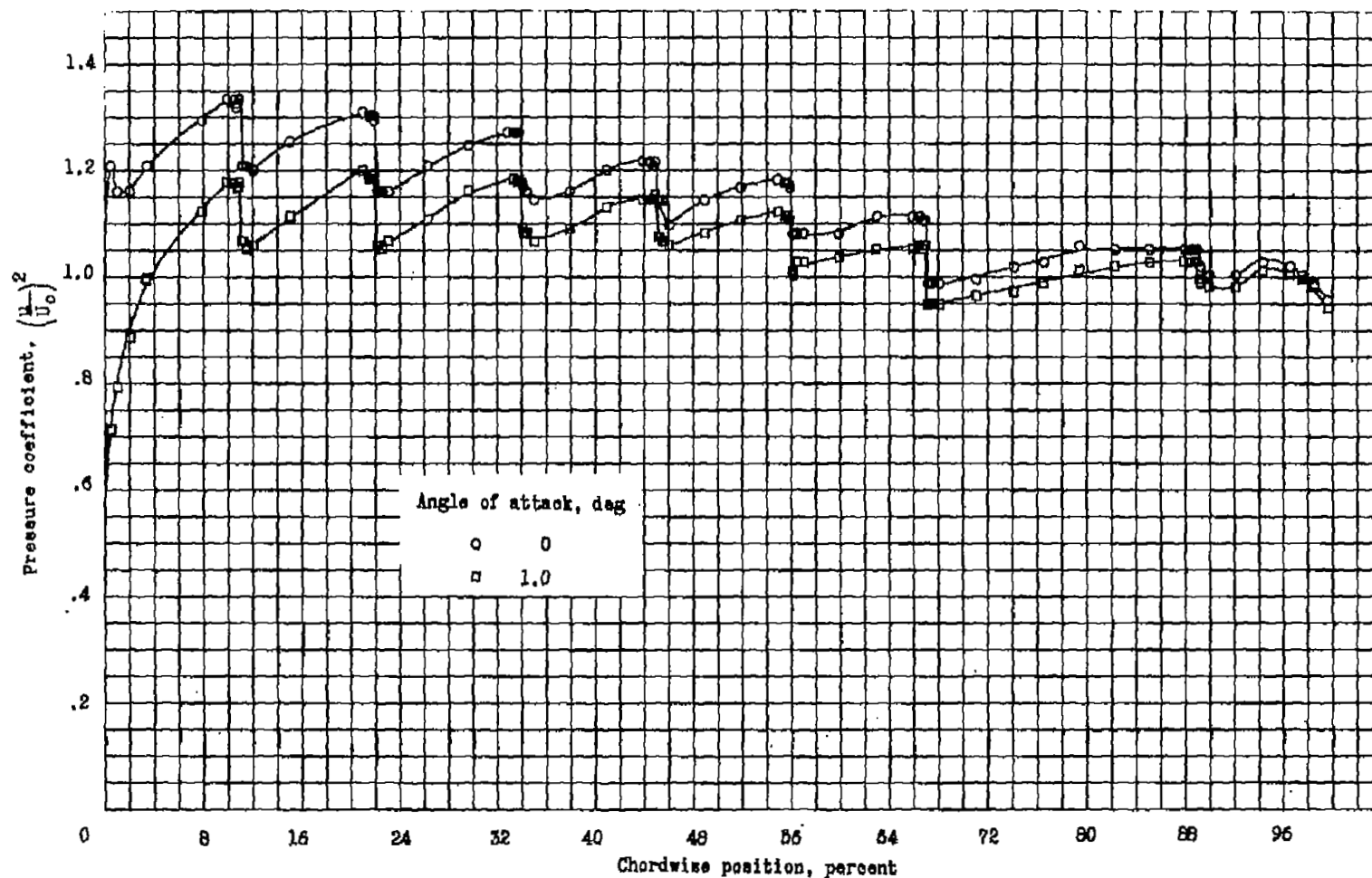for Douglas DESA-2 airfoil section. $R = 5.78 \times 10^6$.

(b) Lower surface.

Figure 5.- Concluded.

(a) Upper surface.

Figure 6.- Experimental pressure distribution about Douglas DESA-2 airfoil
section at angles of attack of 0° and 1.0°. R = 7.8 × 10⁶.

(b) Lower surface.

Figure 6.- Concluded.